

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a system for detecting the presence of a tube connector at the input of an instrument and for identifying it as belonging to a certain class, so as to affect a decision process in the instrument.

Specifically, the present invention can be used to verify that an acceptable type of tube assembly has been properly connected to the panel of a capnograph.

The principles and operation of a connector identifier according to the present invention may be better understood with reference to the drawings and the accompanying description.

Referring now to the drawings, Figure 2 illustrates the essential part of the female member 10 of the tube connector, modified according to a preferred embodiment of the invention. Basically, this is the standard female connector member (which will be referred to herebelow simply as a connector), as depicted in Fig. 1), typified by a slightly conical inner wall 11. The modification calls for the annular face 12 of its end (which is the end closest to the instrument panel) to be specularly reflective to light. The reflectivity may be obtained, for example, by coating the surface with a suitable reflective layer 13 or by polishing the surface to a glossy finish. A preferred method is to hot-press (or stamp) a reflective foil called Foil SLM, available from Kurz Ltd, Germany ; it is particularly suitable when the connector material is made of ABS. As will be seen herebelow, the reflective surface need not extend over the entire width of end face 12, but it must form a complete annular ring, since the luer may be connected to the panel in any angular orientation. A female connector with such a reflective annular surface on its end face will be referred to herebelow as a proper connector, and any other connector - as an improper connector.

Fig. 3 shows a face-on view of the essential part of the matching male connector member 14, which is mounted on the panel ²⁰ of the analyzing instrument ²⁸, the central, slightly conical protrusion 16 fits inside the end of female connector 10 of Fig. 2 in such a manner that end face 12 of connector 10 is parallel to, and at a certain distance from, the annular surface 18 of

male connector 14 that surrounds central protrusion 16. Through the back-plate 19 of male connector 14 there have been drilled two small holes 15, at a mutual distance of about 1.5 mm center-to-center, so that they form openings that face end face 12. Inside each hole 15 is mounted, respectively, an end of one of two optical fibers 21 and 22 that run inside the instrument. The fibers are mounted so that their end faces are flush with, or slightly sunk behind, annular face 18 of back-plate 19.

The other end of fiber 21 is optically coupled to a light-emitting diode (LED) 23, while the other end of fiber 22 is optically coupled to a photodiode (PD) 24. Both LED 23 and PD 24 are mounted at a convenient location inside the instrument and are, respectively, connected to electric circuits 25 and 26. Electric circuit 25 generates a train of current pulses, at a rate of, say, approximately 1 kHz, which are driven through LED 23 and cause it to emit corresponding light pulses. The pulse train frequency is chosen so that this light can be easily discriminated from ambient light, including artificial lighting (which usually has power line frequencies and their harmonics). These light pulses are transmitted through fiber 21 and emitted at its end that is mounted in connector 14. If a proper female connector 10 is in place, its reflective end face 12 reflects an appreciable portion of the emitted pulsed light into the adjacent end of fiber 22, which transmits it to PD 24. This reflected and retransmitted light is detected by PD 24, which converts it to corresponding current pulses in circuit 26. It is noted that, according to standards for the dimensions of the connectors, the distance between end face 12 and surface 18 may be between 0.6 and 1.8 mm and this assures proper coupling of light between the fibers by specular reflection off the end face; however, in order to assure that the distance is not less than 0.6 mm, a pair of 0.6 mm spacers 17 are appropriately mounted on surface 18.

It is appreciated that the LED is provided within a preferred embodiment, but that other types of a light source may be used for coupling to fiber 21.

Referring now to Fig. 4, circuit 26 includes an amplifier 31, to whose input PD 24 is connected, followed in order by synchronous detector 32, integrator 33 and comparator 34. Amplifier 31 amplifies the pulses induced in PD 24, then synchronous detector 32 multiplies

them by a synchronous pulse train obtained from circuit 25. The latter operation is advantageously done in order to distinguish between reflected light pulses and any ambient light that may penetrate into fiber 22. The resultant signal is rectified, to produce a direct voltage. This voltage is integrated by integrator 33 over a certain time period - to yield a voltage value, which is compared in comparator 34 with a threshold value, resulting in a binary signal. This signal, which indicates whether or not light pulses have been reflected from fiber 21 into fiber 22 and, therefore - whether the proper connector is properly in place, is applied to other parts of the instrument, to accordingly enable or disable the operation of crucial components, such as the fluid-drawing pump, and to turn a warning, or indicator, light on or off.

The threshold value is chosen to be such that would discriminate between integrated voltage values that result from specular reflection of light pulses from fiber 21 into fiber 22, as effected by end face 12 of a proper female connector 10 (that is, one that has been treated according to the present invention) properly placed, on the one hand, and values that result from diffuse reflection, such as may be effected by the uncoated and untreated end face of any other female connector (which is, therefore, considered to be an improper connector), or from an improperly placed proper connector, on the other hand.

It is appreciated that circuit 25 can also generate current waveforms other than pulses and that circuit 26 can detect resultant signals in a manner similar to that described hereabove or in any other manner known in the art. According to a refinement of the apparatus disclosed herein, there is placed an optical filter²⁷ which selectively transmits the band of wavelengths emitted by LED 23, either in front of fiber 22 within corresponding hole 15, or between fiber 22 and PD 24; this filter²⁷ is further instrumental in distinguishing between reflected light and ambient light.

According to an alternative configuration of the present invention, the reflective coating on end face 12 of female connector 10 is made to be spectrally selective, that is, it is made to reflect light of certain wavelengths or within a certain bandwidth. This can be achieved, for example, by having the reflective material itself contain dyes or pigments, or by coating the

reflective layer with a suitable spectral filter. This configuration may be advantageously applied, for example, to discriminate between several subclasses of tube assemblies and matching each subclass to a corresponding type of analyzing instrument. For such an application, each type of instrument is provided with a light source having a unique spectral
5 characteristic and the reflection spectrum of each subclass of the tube assembly is made to match. Alternatively, the spectral bandwidth of the light source is broad and identical in all the types of instruments, but a filter in the path of the reflected light (as described above) is given a unique spectral characteristic; according to one practical embodiment, this filter may be identical to the one placed over the reflective surface of the end face (as suggested above).

10 According to another alternative configuration of the present invention, end face 12 of female connector 10 is coated with a fluorescent or phosphorescent material, which is not necessarily specularly reflective. LED 23 is of a type that emits wavelengths short enough to stimulate fluorescence or phosphorescence in the material. There is placed an optical filter,²¹
15 optical filter/²¹selectively transmits the strongest wavelengths emitted by the fluorescent or phosphorescent material, while substantially attenuating wavelengths emitted by LED 23. The rest of the apparatus is as described hereabove. Although this configuration involves generally higher costs for treating the end of the connector than does the first configuration, it has two advantages:

- 20 (a) There is a high degree of discrimination between light reflected from a proper connector and light reflected from any other connector, since the optical filter²¹ can be made to greatly attenuate the wavelength band emitted by LED 23 (which is the only band present in light reflected by improper connectors).
- (b) Different types of fluorescent or phosphorescent materials, having different spectral
25 emission characteristics (or spectral profile), can be chosen; these can be assigned to different classes of connectors for discrimination therebetween.

The second advantage can be realized, for example, by choosing for a particular instrument an optical filter²¹ such that transmits one or more wavelengths at which the

corresponding type of material emits strongly or strongest, while substantially attenuating those wavelengths at which all other types strongly emit. By properly adjusting the threshold level, this would result in an enabling signal being output by the comparator only when a connector of the corresponding class is properly connected to the instrument.

- 5 The fluorescent or phosphorescent material, rather than coated, or painted on the end face, may also be imbedded in the material of which the end face (or the entire connector) is formed. Another way of applying it to the end face is to bond or stamp (e.g. by hot-pressing) to the end face a foil or a film that contains such fluorescent or phosphorescent material.

- According to a refinement of the alternative configuration, applicable in the case of
- 10 phosphorescent materials, there is introduced a certain time delay between the train of current pulses applied to LED 23 and the synchronous pulse train obtained from circuit 25 and applied to the multiplier in circuit 26. The delay time is just greater than the duration of a pulse. The effect of the delay is that the detected light is only that which is emitted by the phosphorescence, excluding, in particular, directly reflected light. This feature further helps
- 15 to discriminate between a proper connector and any other connector and may be used in addition to, or alternatively to, the above mentioned optical filter.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.